CDM

The Hashemite Kingdom of Jordan

Ministry of Water and Irrigation
Water Authority of Jordan

Northern Governorates Water Transmission Feasibility Study

February 2005

المملكة الأردنية الهاشمية

By:
CDM International Inc.

For:
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CDM Project No.: 3029-42324

Volume I - Final Report

NORTHERN GOVERNORATES WATER TRANSMISSION FEASIBILITY STUDY

EXECUTIVE SUMMARY

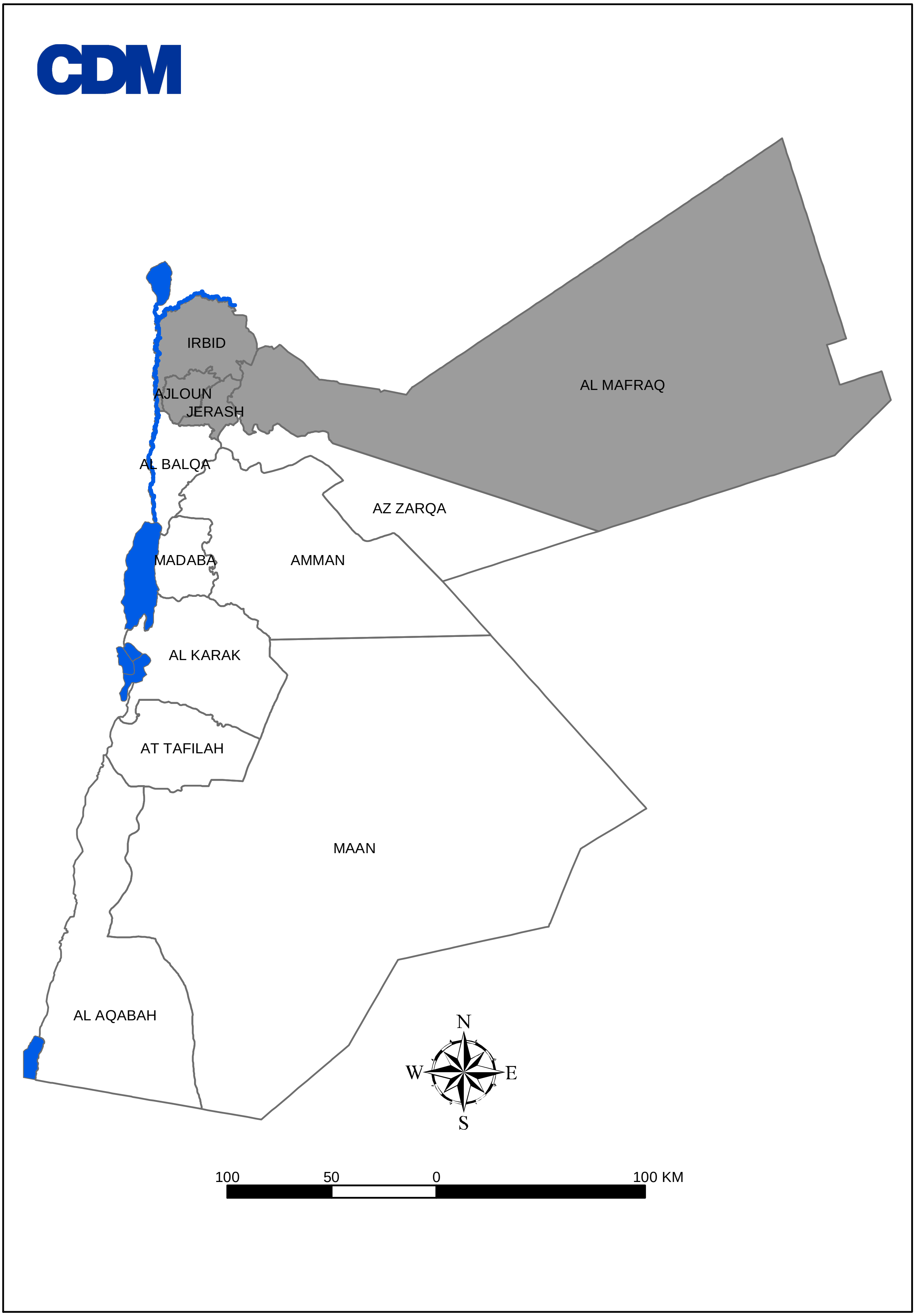
1. INTRODUCTION

The desired output from the Feasibility Study is a prioritized list of projects that are required through year 2030, consisting of municipal water supply facilities needed within the service area of the Northern Governorates Water Authority (NGWA), shown on **Figure 1**. These facilities will comprise water transmission mains and associated components: distribution storage reservoirs, pump stations, water treatment plants, groundwater wells, water-resources facilities and a centralized monitoring and control system.

Work on the feasibility study began in April 2004, and is scheduled for completion in early 2005. A draft Basis of Planning Report was submitted on 1 August, followed by a Basis of Planning Meeting on 17 August, and a final Basis of Planning Report on 1 September 2004 that incorporated changes in response to suggestions and comments by the reviewers of the draft report. A Workshop on Alternatives was conducted on 23 November 2004. The draft Feasibility Report was submitted on 1 December 2004, which was followed by a review meeting on 15 December 2004. This Final Report has been prepared to incorporate responses to suggestions and comments by reviewers, as well as to develop a facilities plan that is fully consistent with the on-going German-funded Water Loss Reduction Program (WLRP).

The study area covers 4 of the 12 governorates of Jordan – Irbid, Ajlun, Jerash and Mafraq – which are served by the Northern Governorates Water Authority (NGWA), an operations unit of the Water Authority of Jordan (WAJ). The study area is bordered to the north by Syria and the Yarmouk River, to the west by the Jordan River, to the south by the Amman-Zarqa metropolitan area, and to the east by Iraq. The northern governorates contained about 1.56 million people in 2003, or about 29% of the national population on 32% of the national land area. The major city is Irbid with a population of 400,000, placing it as the third largest city in Jordan after Amman and Zarqa. In contrast to Irbid, the Mafraq governorate covers a large sparsely-populated desert area, in which the eastern portion contains only isolated settlements that receive water supply from local NGWA wells; this eastern portion of Mafraq has not been considered in any detail in this feasibility study on the water transmission system.

The major population centers served by NGWA are located on a high plateau of rolling hills at elevations ranging generally from 400m to 900m above sea level. However, the study area includes deep wadis and agricultural land along the Jordan River, lying at elevations as low as 200m below sea level; and smaller settlements ranging up to 1200m above sea level. While much of Jordan is arid or semi-arid, the urbanized portion of the study area receives some of the highest annual rainfalls in the country, exceeding 600 mm in some areas. As part of the Fertile Crescent and the ancient Cradle of Civilization, the water resources of the study area have been developed since ancient times. Rainfall statistics show a strong seasonal pattern of precipitation, with 80% of annual precipitation occurring in the 4 winter months of December through March.



Northen Governorates Water Transmission System Feasibility Study
Figure 1: Location of Nothern Governorates

In Ajloun and Jerash, where the karst geology is not favorable for deep wells, the long hot summers and reduction in spring flows (from over-abstraction by wells) have reduced the nature of agriculture in more recent times to olive trees and other rain-fed crops. Although Mafraq receives little precipitation, many deep wells have been installed there to capture groundwater flows, much of it originating in the Syrian highlands. Much of the area is covered by rock and impervious layers, which limit the groundwater infiltration to less than 5% of the annual rainfall. However, the service area is a net exporter of water to the remainder of Jordan, as well as to Israel. The Yarmouk River on the northern boundary of the service area has by far the largest streamflow of any river or wadi in Jordan, with an average annual flow of about 420 MCM (million cubic meters) at its mouth. A significant amount of groundwater also enters the study area from the Syrian highlands, estimated at about 68 MCM. The exported water is the mainstay for irrigation in the Jordan Valley, as well as the municipal water supply for Amman and Zarqa, through the King Abdullah Canal (KAC). The KAC follows the eastern bank of the Jordan River, to supply both irrigation demands and the Zai water treatment plant within the Amman water supply system. In addition, the governorate of Mafraq contains several well fields – the Aqeb and Za'tary well fields – which export water to the Amman-Zarqa water supply systems. As a result, the major difficulty in meeting the future NGWA water demands is that any increase in municipal water use must be made at the expense of other areas within Jordan, or at the expense of irrigation water users in the Jordan Valley or within the study area. As indicated in Section 5, the groundwater abstractions within the study area presently exceed the safe yield of the available groundwater aquifers.

In 2003 the four northern governorates contained about 184,000 NGWA subscribers, who had a metered domestic consumption of about 28 MCM (excluding known or estimated water usage for irrigation, filter backwashing in a water treatment plant, and flushing of water mains). This corresponds to a metered per capita consumption of only 55 lpcd (liters per capita per day). Water is rationed, with most customers receiving water only one or two days each week. Estimating the net water production delivered to the 4 governorates requires a complex set of calculations to account for the import and export of water to/from the NGWA transmission mains, and to/from the areas outside the NGWA service area (principally to Zarqa and Amman). The net production of about 58 MCM corresponds to 107 lpcd, which is also quite low by world standards (typically 200 to 500 lpcd in many other developing countries, when industrial, commercial, and institutional water uses are included). The unaccounted-for water (UFW) of 44% is high given the scarcity of water in Jordan, but half of the NGWA water losses are concentrated in Mafraq governorate (62% UFW), where the losses are attributable to the relative aridity, lawlessness, and social problems encountered in the eastern portion of Mafraq. In Jerash, Ajloun and Irbid the UFW is much lower, at 28%, 35% and 36% respectively. In Jordan as a whole, the UFW is about 50%, composed of physical losses estimated at 30% and administrative losses estimated at 20%. Several programs are underway countrywide (including the NGWA system) to reduce the physical losses by rehabilitation and restructuring of the distribution networks.

2. PREVIOUS STUDIES AND CURRENT PROGRAMS

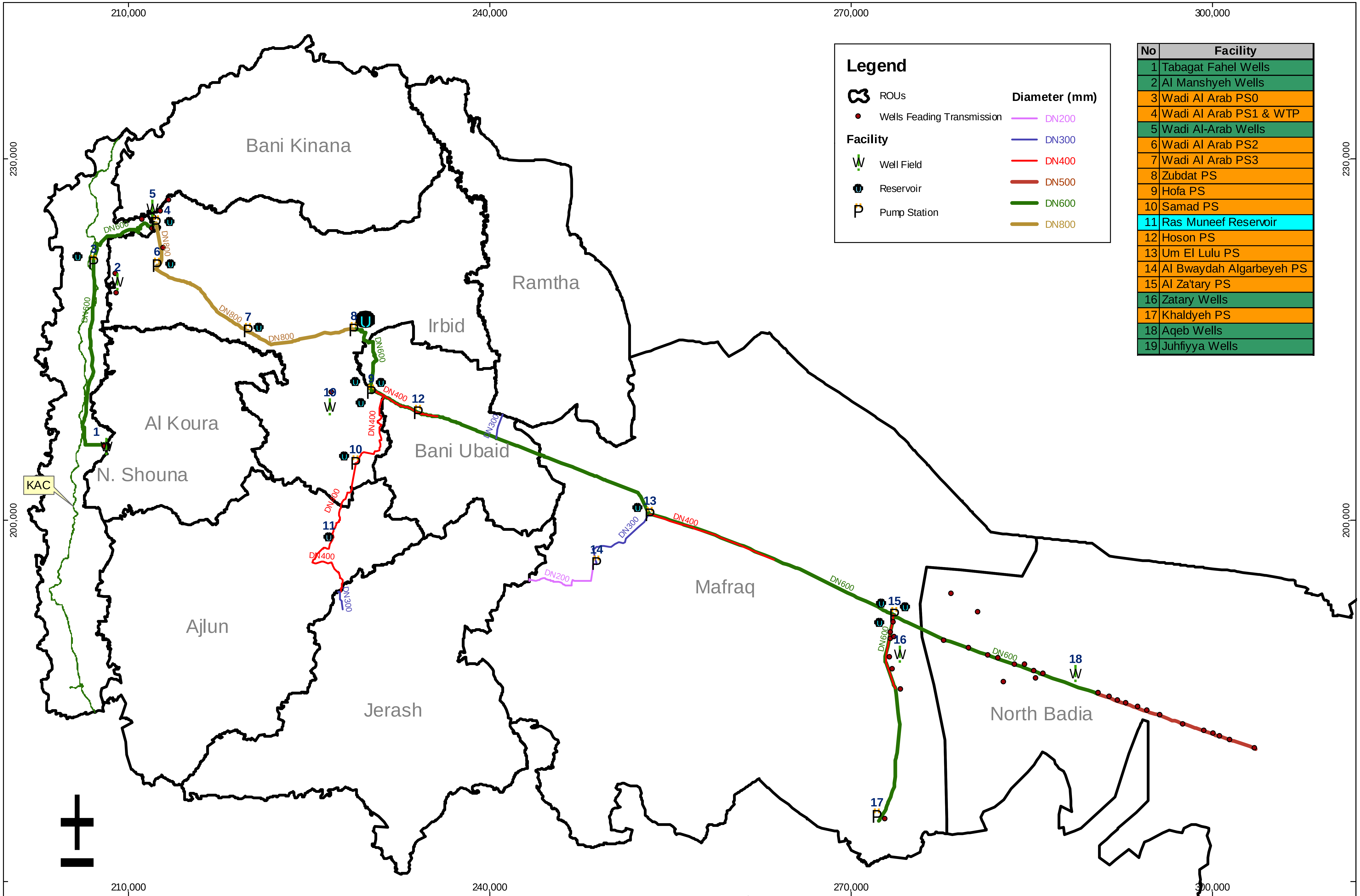
The work on this feasibility study has benefited substantially from several previous studies, which have laid the groundwork to identify new water sources and transmission improvements that will be required through the year 2030. There are also several on-going studies and programs that impact this study.

Previous Studies. Two studies funded by the French government have provided detailed technical information on the existing water supply system, and required improvements in rehabilitation, re-structuring and expansion to meet water demands in 2025. The consulting firm SOGREAH covered the governorates of Irbid, Jerash and Ajloun in a study entitled *Hydraulic Analysis of the Water Systems in Irbid Governorate,* printed in 12 volumes plus a set of drawings in AutoCAD. SAFEGE conducted a similar study for the remaining governorate, entitled *Hydraulic Analysis of the Water Systems in the Mafraq Governorate* printed as 7 reports in 21 volumes. Both studies were completed in 1998, and both covered topics relevant to this study. Subsequently, NGWA has transferred the data on existing pipelines mapped in the two French-funded studies from AutoCAD drawings into a GIS database. This GIS database in turn has been used in this feasibility study; the same pipe designations have been retained, to allow for a future comparison of the required sizes of future pipelines. In addition, there have been many previous studies on development of new water sources: the Unity Dam (Al-Wehdeh Dam) on the Yarmouk River (currently under construction); the Mukheiba wells near the mouth of the Yarmouk River; and two national water master plans (a JICA-funded plan in 1999, and a GTZ-funded plan first presented in a seminar on 18-19 July 2004).

On-going programs. This feasibility study is being coordinated with three on-going programs: the GTZ-funded OMS program (Operations Management Support), which has assisted in the development of a GIS mapping and database system within NGWA; the KfW-funded Water Loss Reduction Program (WLRP), which is developing designs for rehabilitation, restructuring and expansion of local distribution networks to reduce physical water losses and support continuous rather than intermittent supplies; and the GTZ-funded National Water Master Plan (NWMP) of the Water Master Planning Directorate within the Ministry of Water and Irrigation (MWI).

3. EXISTING NGWA WATER SYSTEM

NGWA faces the daily challenge of operating a large number of local distribution networks that have been built to a low standard, and have inadequate hydraulic capacity to deliver good water service. Locations of the major existing transmission facilities are shown on **Figure 2**. While the existing transmission system is fairly new and in good condition, the local distribution networks were developed under severe time and money constraints. The GIS database provides several indicators of the extent of the deficiencies. Of the 5600 km of pipe in the NGWA system, almost half of the pipes are 50 mm (2-inch) diameter or less; only 10% of the pipes are 200 mm (8-inch) or larger. As an indication of the contrast with other countries, many USA cities have a minimum pipe size of 200 mm, although this is primarily to provide fire protection rather than normal water service. Almost 80% of the pipe materials in the system are susceptible to rapid corrosion and deterioration, particularly the small galvanized iron pipes and the larger steel pipes. The French-funded studies found that more than half of the pipes are above-ground pipes, exposed to damage from traffic or to tampering.



No	Facility
1	Tabagat Fahel Wells
2	Al Manshyeh Wells
3	Wadi Al Arab PS0
4	Wadi Al Arab PS1 & WTP
5	Wadi Al-Arab Wells
6	Wadi Al Arab PS2
7	Wadi Al Arab PS3
8	Zubdat PS
9	Hofa PS
10	Samad PS
11	Ras Muneef Reservoir
12	Hoson PS
13	Um El Lulu PS
14	Al Bwaydah Algarbeyeh PS
15	Al Za'tary PS
16	Zatary Wells
17	Khaldyeh PS
18	Aqeb Wells
19	Juhfiyya Wells

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THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF WATER AND IRRIGATION
WATER AUTHORITY

CDM International Inc.

NORTHERN GOVERNORATES WATER TRANSMISSION SYSTEM FEASIBILITY STUDY

Existing Transmission System Layout

PROJECT No. 3029-42324

FIGURE No. 2

NGWA has installed an extensive system of bulk water meters to measure the flows produced from wells and springs, and the transfers of water between portions of the system. The results have been used in this study to develop a verified hydraulic model of the existing transmission system, which serves the most heavily-urbanized portions of the service area. In addition, under this study, the rehabilitation requirements for improvements at well-heads and pump stations have been identified, and two reports completed: one dealing with electrical and instrumentation requirements; and a second dealing with mechanical requirements.

The NGWA service area is divided into ten ROUs (Regional Operations Units), shown on **Figure 2**. The system contains 199 water sources, measured at 148 locations (individual wells, well fields, or springs). During 2003, total water production of 70.1 MCM (million cubic meters) was obtained from 93 locations, as summarized in **Table 1** by ROU and by portion of the transmission system (East and West). A portion of the production was exported to Amman and Zarqa , and 58.8 MCM was delivered to the northern Governorates (this value excludes losses in the East and West transmission systems). The major well fields are shown on **Figure 2**; these include the Tabaqat Fahel and Wadi Al Arab well fields in the West transmission system, and the Aqeb and Zatary well fields in the East transmission system.

Table 1 Summary of Water Production in 2003

Gvrte.	ROU or System	Number of Water Sources: Operating/Total				Production in 2003		
		Single Wells	Springs	Well Fields	Total Sources	CM/Yr	CM/day	CM/hr
Ajloun	Ajloun	2 / 4	5 / 7	1 / 2	8 / 13	2,626,868	7,197	300
Irbid	Al-Koura	2 / 4	0 / 0	2 / 2	4 / 6	2,651,783	7,265	303
Irbid	Bani Kanana	2 / 5	0 / 0	1 / 3	3 / 8	479,163	1,313	55
Irbid	Bani Ubaid	1 / 1	0 / 0	2 / 2	3 / 3	406,224	1,113	46
Irbid	Irbid	3 / 4	0 / 0	9 / 9	12 / 13	3,157,845	8,652	360
Irbid	North Shouneh	5 / 10	1 / 1	0 / 0	6 / 11	1,369,672	3,753	156
Irbid	Ramtha	7 / 7	0 / 0	5 / 6	12 / 13	1,582,391	4,335	181
Jerash	Jerash	4 / 9	3 / 7	4 / 5	11 / 21	2,711,481	7,429	310
Mafraq	Mafraq	4 / 9	0 / 0	6 / 7	10 / 16	7,159,874	19,616	817
Mafraq	North Badia	4 / 13	0 / 0	9 / 12	13 / 25	5,486,193	15,031	626
Subtotal, ROUs		**34 / 66**	**9 / 15**	**39 / 48**	**82 / 129**	**27,631,494**	**75,703**	**3,154**
East Transmission		0 / 4	0 / 0	3 / 3	3 / 7	22,666,026	62,099	2,587
West Transmission		6 / 10	0 / 0	2 / 2	8 / 12	19,776,635	54,183	2,258
Subtotal, Transmission		**6 / 14**	**0 / 0**	**5 / 5**	**11 / 19**	**42,442,661**	**116,281**	**4,845**
TOTALS		**40 / 80**	**9 / 15**	**44 / 53**	**93 / 148**	**70,074,155**	**191,984**	**7,999**

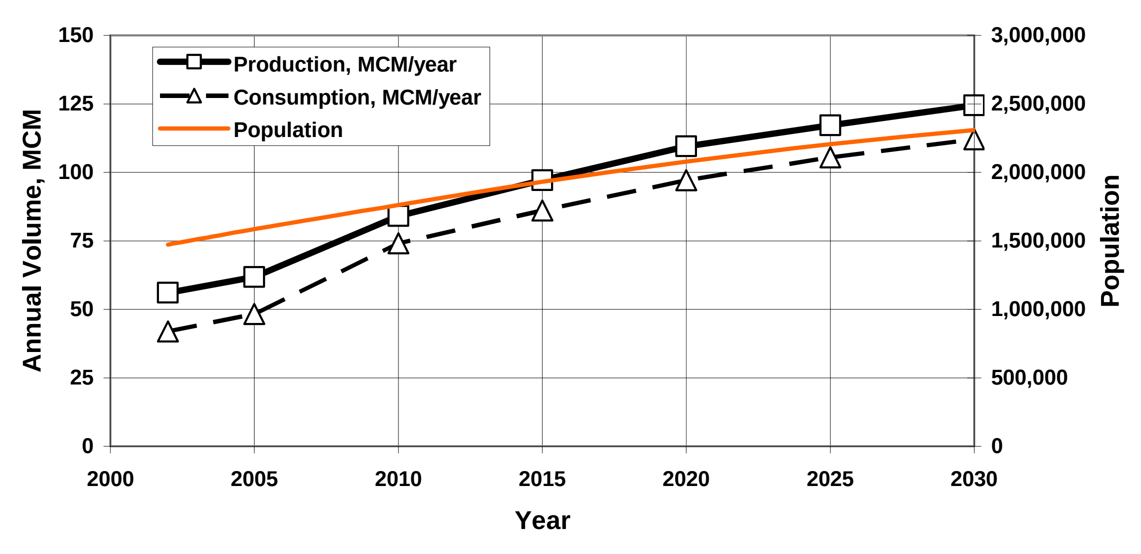
Note 1: NGWA exports about 11.3 MCM to other Governorates; its share of its production is 58.8 MCM
Note 2: CM = cubic meters

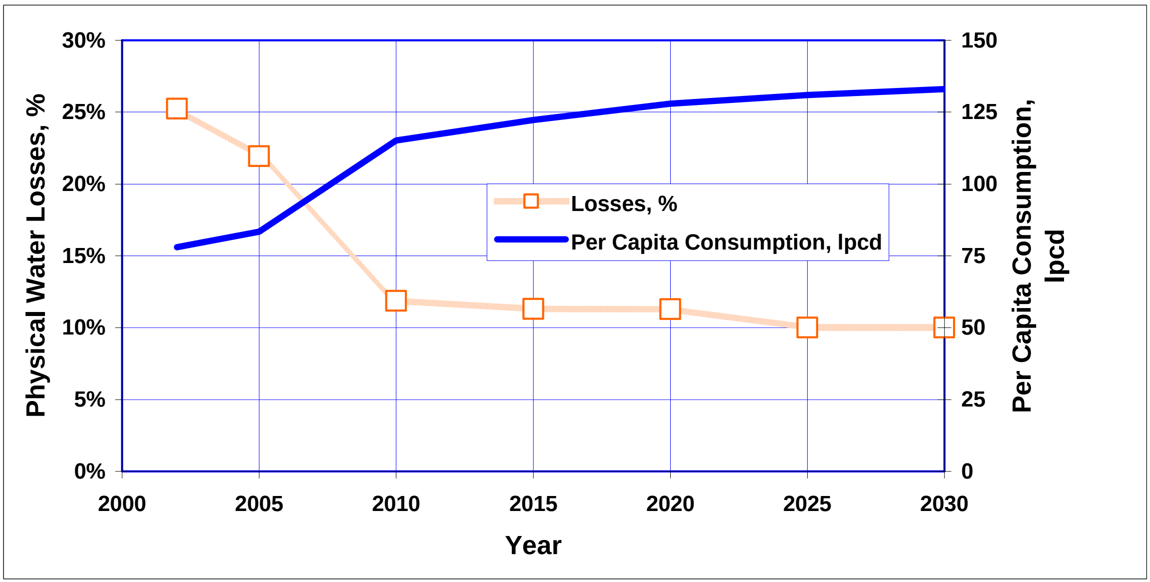
4. POPULATION AND DEMAND FORECASTS

A population forecast to year 2030 has been made in accordance with a recently-adopted methodology applied by the Department of Statistics, in which the age-sex triangle and cohort fertility/survival trends are taken into account; as a result, the population forecast is lower than the forecast adopted in previous studies. A demand forecast has been prepared that allows about 10 years (until 2015) to re-build and rehabilitate the local networks and reduce physical losses (leakage) to 10% of the water production. The forecasts are summarized below in **Figure 3**.

Figure 3 Summary of Water Forecast, NGWA Service Area

Item	2002	2005	2010	2015	2020	2025	2030
Population	1,471,340	1,584,821	1,761,526	1,929,948	2,079,043	2,206,049	2,308,207
Potential Per Capita Demand, lpcd	133	129	137	138	144	146	148
Potential Water Demand, MCM/year	71.3	74.6	87.8	97.1	109.5	117.2	124.5
Deficit in Supply, MCM/year	15.3	12.8	3.8	0	0	0	0
Production, MCM/year	56.06	61.84	84.03	97.08	109.50	117.20	124.50
Consumption, MCM/year	41.91	48.28	74.05	86.11	97.13	105.48	112.05
Physical Losses, %	25.2%	21.9%	11.9%	11.3%	11.3%	10.0%	10.0%
Per Capita Use, lpcd	78	83	115	122	128	131	133
Avg. Demand, m3/hour	6,400	7,060	9,592	11,082	12,500	13,379	14,213
Max. Day Demand, m3/hour	7,680	8,472	11,511	13,298	14,999	16,055	17,055





5. EXISTING AND POTENTIAL WATER SUPPLY SOURCES

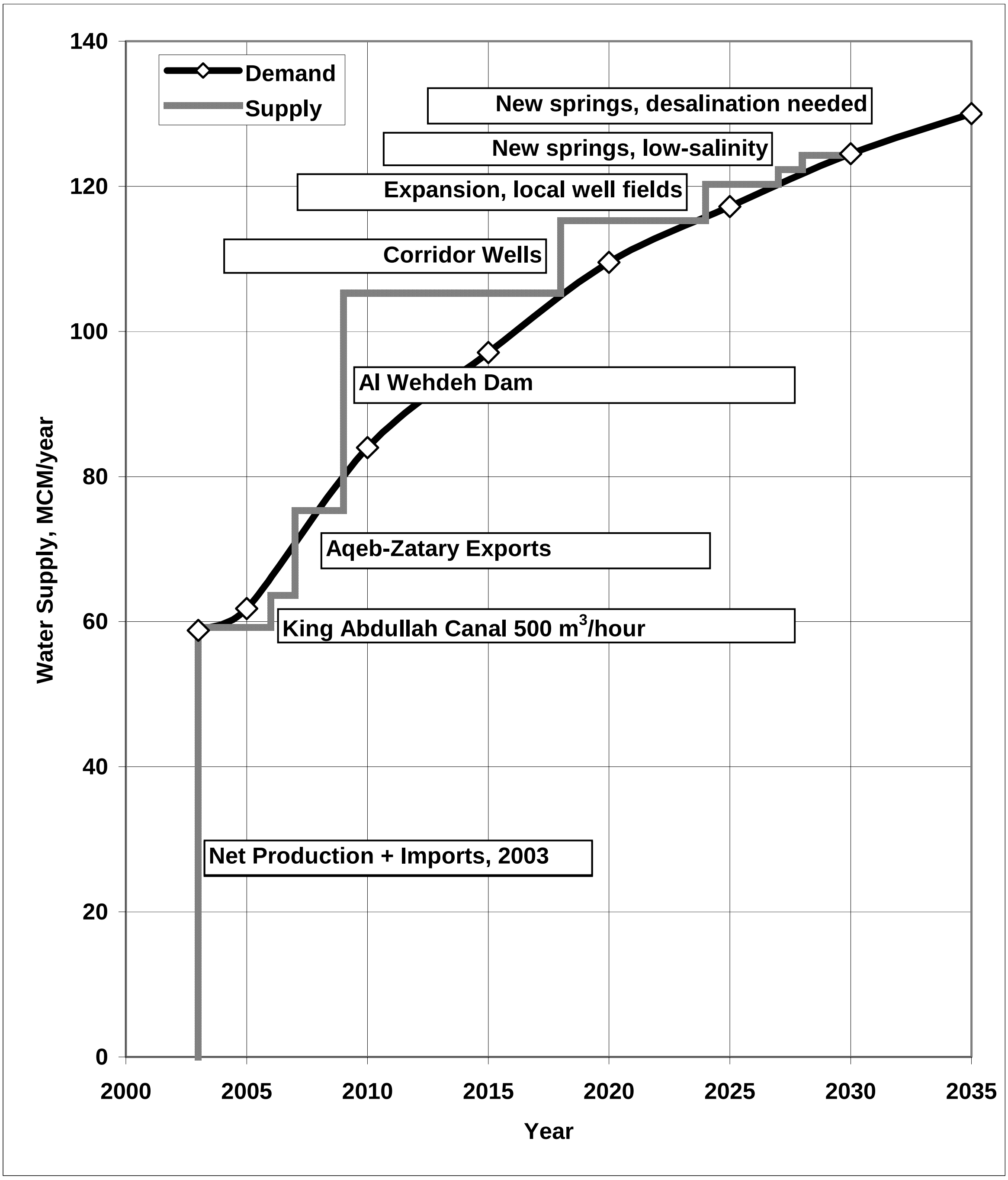
An extensive review has been carried out of the aquifer systems and major groundwater basins in northern Jordan, and the water uses both for public water supply and private water use (primarily for irrigation). As in many previous studies, it is concluded that groundwater levels are dropping in all the major aquifers and basins, and that groundwater abstractions exceed the safe yield from groundwater recharge.

Reducing the groundwater abstractions to a sustainable level, while meeting the forecast of NGWA water demand, will require several measures: re-allocation to NGWA of water exports from the Aqeb and Zatary well fields, presently exported to the Amman-Zarqa water systems; reduction of irrigation water demands by several means (water pricing, reduced allocations, efficiency improvements, wastewater reuse, buy-out of wells, transfer of irrigation use from the highlands to the Jordan Valley, control over illegal wells); and possible development of several springs in the Jordan Valley, subject to constraints or mixing with other sources to reduce salinity to useable levels. Water quality has been examined, and it is concluded that all the existing and potential water sources (except the high-salinity springs) can be treated relatively easily to achieve the Jordan drinking water standards.

The key issue, resolved in collaboration with the NWMP (National Water Master Plan), is the allocation of water sources to the northern governorates over the planning horizon extending to year 2030. The phased expansion of the NGWA system to year 2030 adopted for this study is shown on **Figure 4**, for 9 existing and potential sources of water. These include:

1. The NGWA net production in 2003 of 58.8 MCM. It is assumed that the production from the existing wells will remain constant, and that some of the wells that were not operated in 2003 could be operated to meet seasonal peak demands, including the maximum daily demand which is targeted at 120% of the average demand.
2. The small amount of water imported from Balqa and Zarqa governorates in 2003, amounting to 0.4 MCM.
3. An allowance of 500 m^3/hour to NGWA from the King Abdullah Canal. After treatment, the water can be carried to Irbid by the existing Wadi Al-Arab system, without any expansion required in pumping or pipe capacity.
4. Re-allocation to NGWA of the water exported to Amman and Zarqa water supply from the Aqeb-Zatary well fields in 2003, amounting to 11.7 MCM.
5. The Yarmouk River allocation of 30 MCM to NGWA under the NWMP, to come from the Al Wehdeh Dam, currently under construction.
6. The Corridor wells currently supply about 10 MCM to the Amman-Zarqa water system, and have required a significant investment in large long pipelines. The MWI has indicated recently that the Corridor wells would be made available to NGWA late in the planning period, when Amman and Zarqa have water available from the Disi project.

Figure 4 Phased Expansion of Potential Water Sources



Water Source	Supply MCM	Total Supply Cum MCM	Year On-Line
Net production, 2003	58.8	58.8	2003
Existing imports from Balqa & Zarqa	0.4	59.2	2003
King Abdullah Canal, 500 m^3/hr	4.4	63.6	2006
Aqeb-Zatary wells, reallocated from Amman-Zarqa	11.7	75.3	2007
Al Wehdeh Dam, allocation from Yarmouk River Basin	30.0	105.3	2009
Corridor wells, re-allocated from Amman-Zarqa	10.0	115.3	2018
Expansion of well fields serving local systems	5.0	120.3	2024
New springs, low salinity when mixed	2.0	122.3	2027
New springs, desalination of brackish water	2.0	124.3	2028

7. Local wells serving small local systems. Under the WLRP, a number of local water systems have been identified that serve villages and rural areas, which cannot be supplied conveniently or economically from the transmission system. These local systems are (and will continue to be) supplied by local groundwater wells. Additional wells, or wells of increased capacity, will be required to meet the localized growth in water demand, which is estimated at 5 MCM in 2025 by the WLRP. The timing for expansion in local well capacity will be spread over the planning period, from 2005 to 2030, depending upon local circumstances.
8. In Section 5 of this report, several springs are investigated as potential new sources of water for NGWA. Two of the springs have relatively low salinity, and could be blended with the remaining sources of water for the West transmission system, to increase the supply by about 2 MCM.
9. Two of the springs have relatively large flows, but are too salty for direct potable use; expensive desalination of brackish water will be required, to obtain an estimated additional supply of about 2 MCM.

6. PLANNING AND DESIGN CRITERIA

Planning and design criteria have been developed to establish a common basis for the subsequent comparison of technical alternatives, in addition to establishing the target performance criteria for the planned water supply improvements. The relevant criteria include peaking factors applied to average daily demands, water treatment requirements, and unit costs of construction by type of facility (pipes, pump stations, and reservoirs).

The current WLRP study is developing conceptual designs for about 101 local distribution networks, each to be fed from a local distribution reservoir. The WLRP finished a conceptual design in mid-August, and provided results before and after that date, which have been used in this study for the hydraulic modeling and design of the transmission system. The key results to be achieved in this study are the layout and pipe sizes for transmission mains required to meet the year-2030 water demands.

We propose that the transmission system be designed to carry the maximum-daily demand for continuous supply to the local distribution reservoirs, which in turn will be sized to handle emergency storage and active storage sufficient to handle peak-hour demands. There is relatively little experience data in Jordan on continuous supply systems and their associated maximum-daily demands. A demand factor of 1.2 is advocated in this report, as a reasonable target for the ratio of maximum-daily to average-daily demand.

7. ALTERNATIVE TRANSMISSION SYSTEMS

A preferred future transmission system for the northern governorates has been identified by comparison of three different alternative systems. The basic rationale for each alternative has been as follows:

- Alternative 1 incorporates the best judgment of the investigators, and the results from detailed field investigations and cooperation with NGWA senior staff. The general objective has been to minimize total pipe length and capital cost, and to achieve near-minimal power cost for pumping.

- Alternative 2 incorporates certain alternative pipeline routings for the flow, where it seemed possible that the number of pump stations might be reduced, or the total pumping costs might be reduced, but the most economical solution could only be determined by a detailed cost comparison.
- Alternative 3 incorporates the basic layout from previous studies, primarily those of SAFEGE and SOGREAH; the planning and design criteria have been updated to provide a consistent basis of comparison with Alternatives 1 and 2.

Of these alternatives, Alternative 1 (shown on **Figure 5 and Figure 6**) was found to have the lowest capital cost, the lowest annual power cost for pumping, and the fewest number of pump stations (to minimize labor costs). As a result, Alternative 1 is the preferred alternative for development of the transmission system through the year 2030.

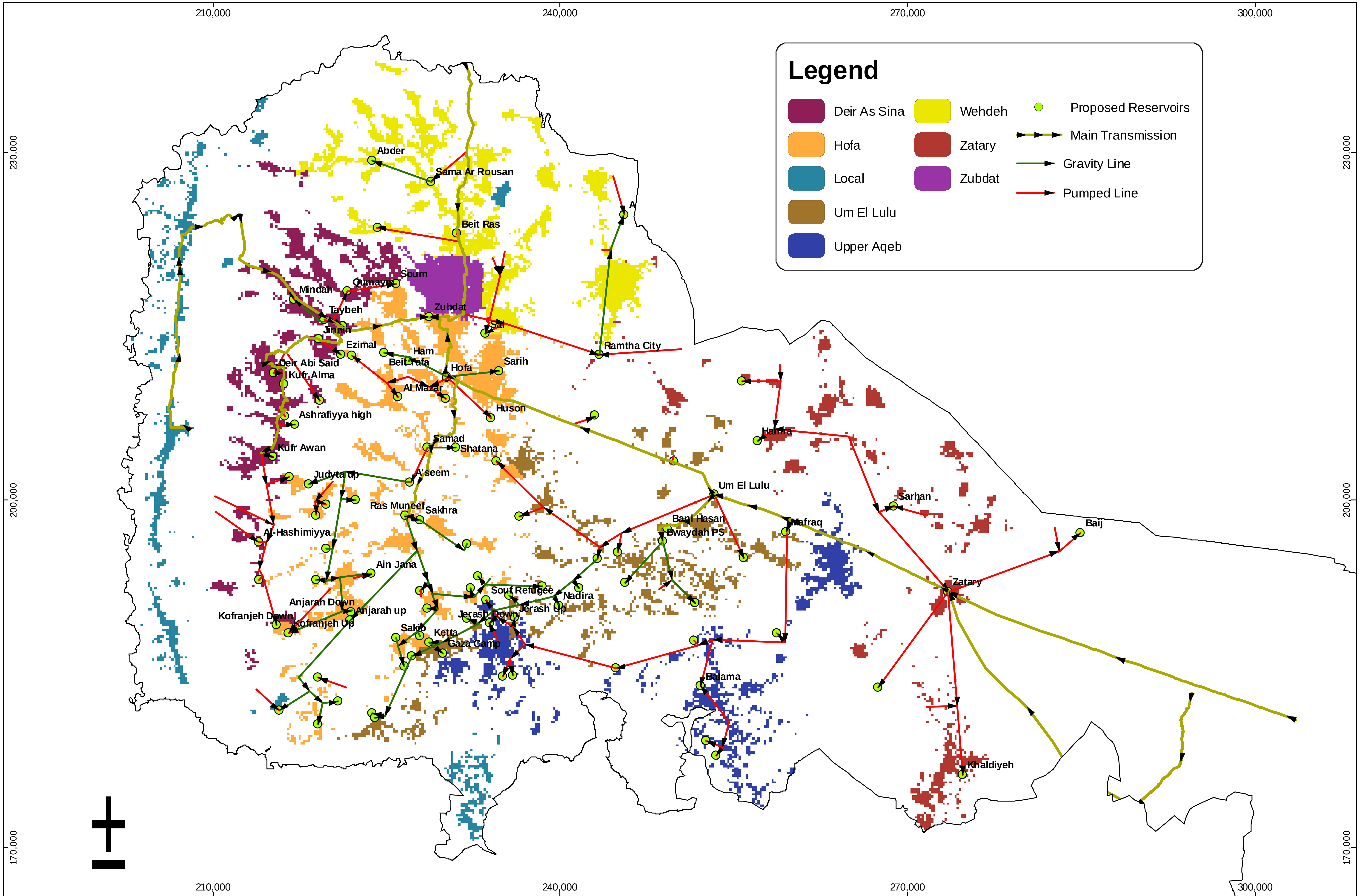
8. PROPOSED PROJECTS

The phased development of the transmission system to year 2030 has been divided into ten proposed projects, of which four projects relate to the primary transmission system and six projects relate to geographic subsystems containing both transmission and local distribution facilities. The pipelines and reservoirs for the ten proposed projects are shown in **Figure 7**, and the estimated costs of the projects are listed in **Table 2**. The sequence of development of the water sources and the transmission/distribution facilities, and the linkages between them, are illustrated in **Figure 8,** implementation schedule in **Figure 9** and the construction costs by project / year on **Figure 10**. Given the large existing deficiencies in capacity of transmission facilities, compared to the water demands, 3 of the 4 proposed water sources are proposed to be completed by 2009. Construction on the subsystems would be spread out over the period to year 2015, to reduce the expenditures concentrated in the years up to 2009. In addition to new transmission and distribution facilities, a centralized monitoring and control system and rehabilitation of existing pump stations and wells are included in the costs for each project. Costs of small distribution pipes and appurtenances are not included in Table 2; in the WLRP (Water Loss Reduction Program), these types of distribution costs are estimated at $108 million.

Table 2 Estimated Costs of Proposed Projects ($ million)

Project	Reservoirs	Pipes	Pump Stations	Monitoring & Control	Water Treatment	Rehab of Wells, PSs	Total Cost	% of Cost
Primary Transmission								
East System		22.71	1.50	1.53		2.17	27.91	12.1%
West System		0.00	0.88	0.98	7.80	2.18	11.84	5.1%
Wehdeh System	0.71	18.62	7.96	0.36	22.68		50.33	21.8%
Corridor System		6.47		0.31			6.78	2.9%
Subsystems								
Sumaya Khaldiyeh Zatary	2.84	3.03	0.56	0.93			7.36	3.2%
Upper Aqeb/Mafraq	5.48	25.43	0.38	0.66			31.95	13.9%
Um El Lulu	5.82	12.87	0.28	0.74			19.70	8.5%
Hofa	13.27	20.62	2.30	1.26			37.45	16.2%
Bani Kinana/Ramtha	4.87	7.21	0.62	0.43			13.13	5.7%
Deir As Sina	9.48	11.80	1.75	1.13			24.16	10.5%
Total	42.47	128.76	16.22	8.33	30.48	4.35	230.61	100.0%
Percentage of Cost	18.4%	55.8%	7.0%	3.6%	13.2%	1.9%	100.0%	

Notes: Locations of proposed projects shown on Figure 6; distribution costs not included; costs include physical contingencies but exclude engineering costs and inflation allowances; construction costs at 2004 prices.



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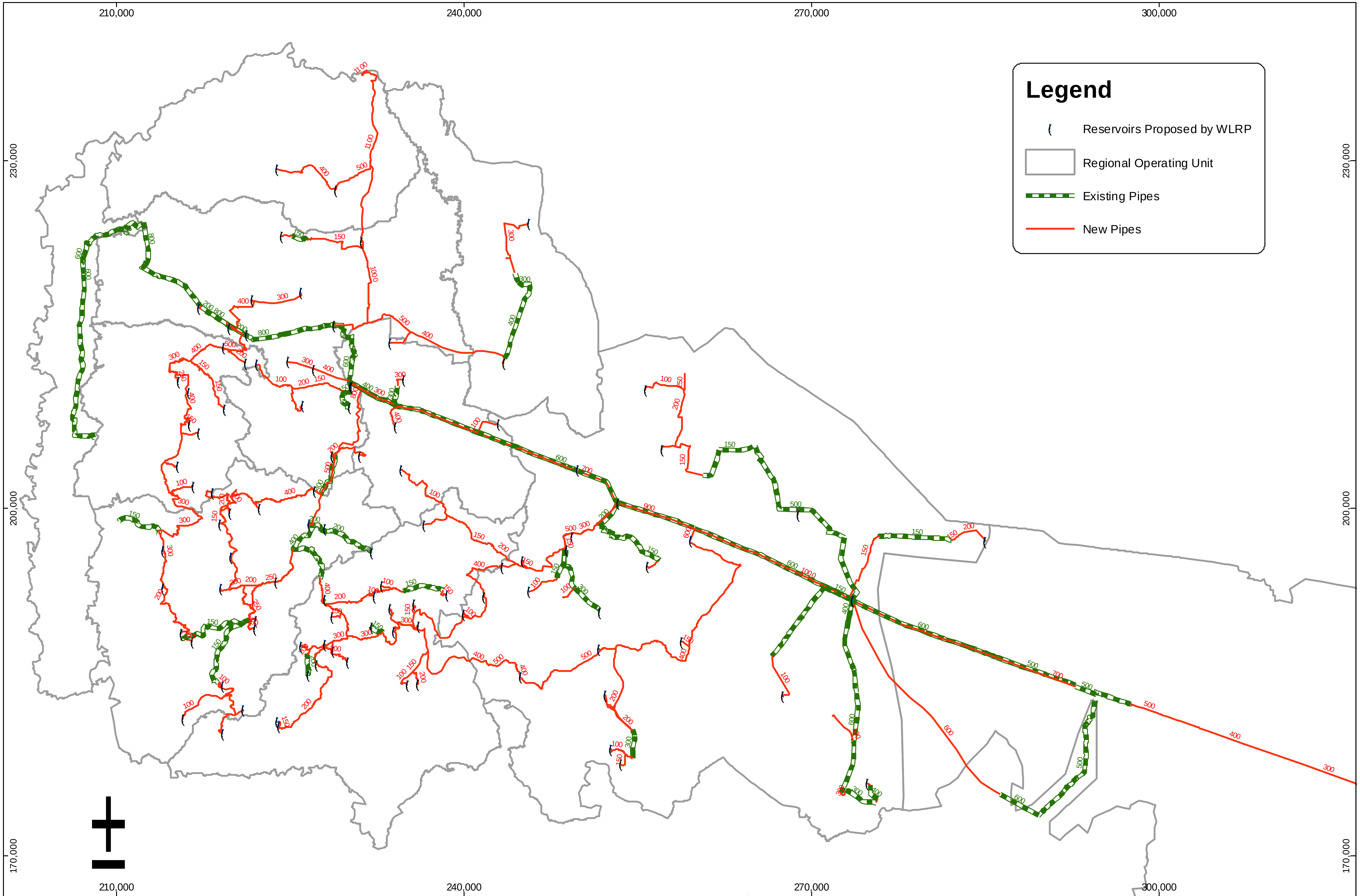
PROJECT No. 3029-42324

FIGURE No. 5



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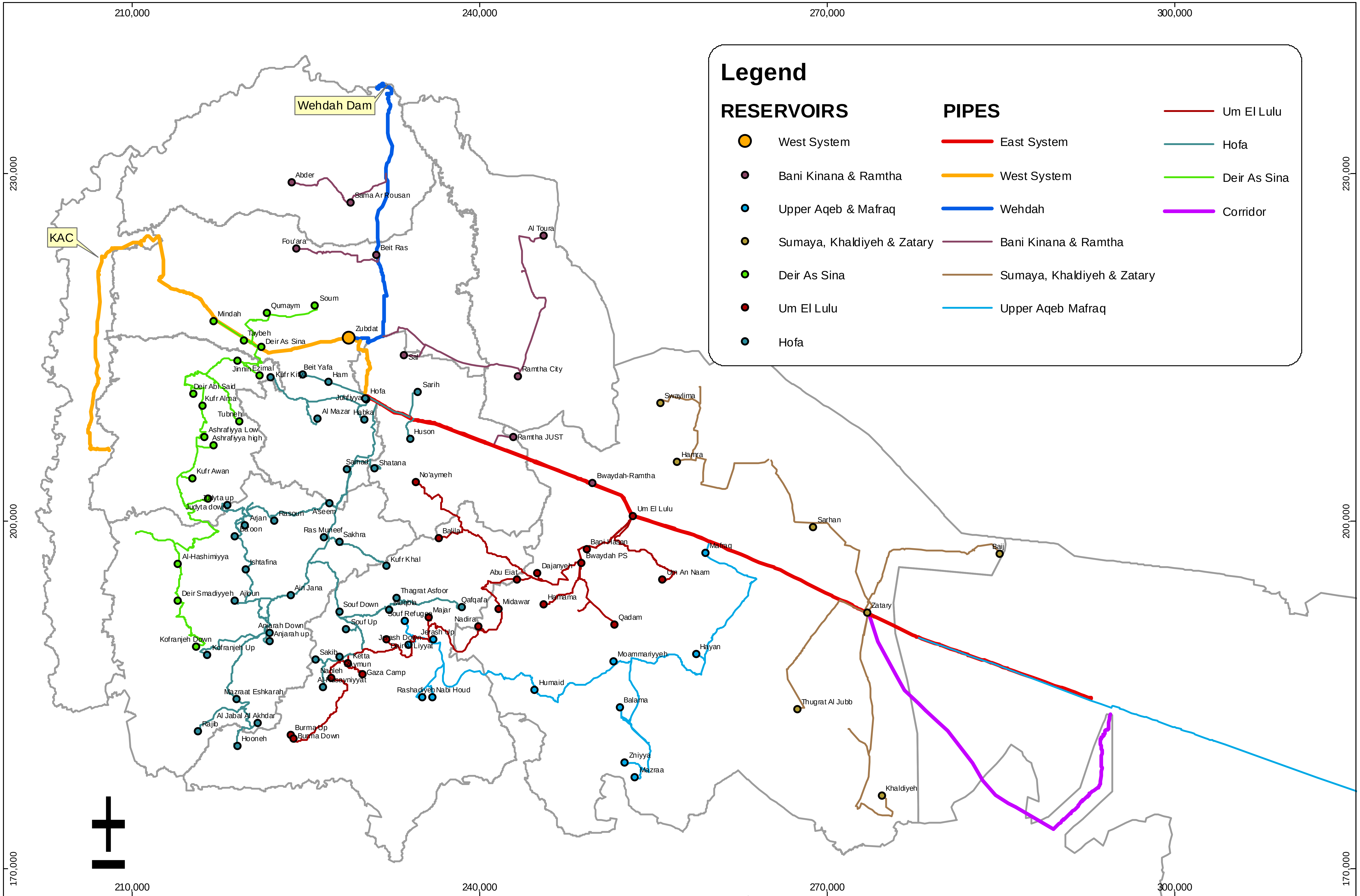
			PROJECT No. 3029-42324 FIGURE No. 6



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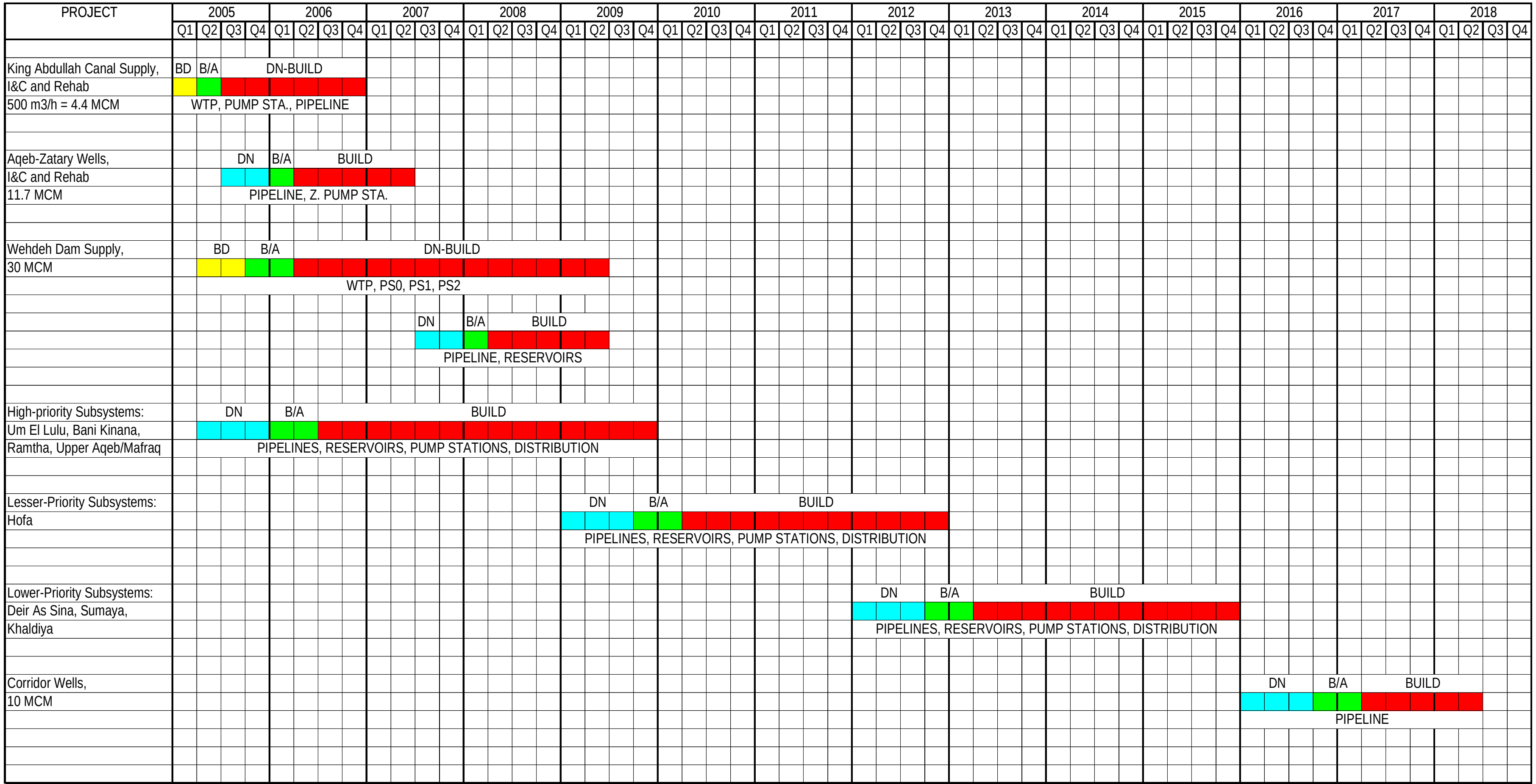
			Proposed Pipeline and Reservoir Projects	FIGURE No. 7

Figure 8 Proposed Sequence in Project Development

YEAR COMPLETED:	2006	2007	2009	2012	2015	2018
SOURCE DEVELOPED:	King Abdullah Canal 500 m3/hour	Aqeb-Zatary Wells 11.7 MCM	Wehdeh Dam 30 MCM	None	None	Corridor Wells 10 MCM
PRIMARY TRANSMISSION PROJECTS:	West System	East System	Wehdeh System	None	None	Corridor System
TRANSMISSION & DISTRIBUTION SUBSYSTEM PROJECTS:	None	Um El Lulu	Bani Kinana Ramtha UA/Mafraq	Hofa	Deir As Sina Sumaya Khaldiya	None
MONITORING & CONTROL SYSTEM PROJECTS:	Existing System	East System	West System	Three Subsystems	Three Subsystems	Corridor System
REHABILITATION PROJECTS:	Existing System	Existing System	N/A	N/A	N/A	N/A

Figure 9 Proposed Implementation Schedule

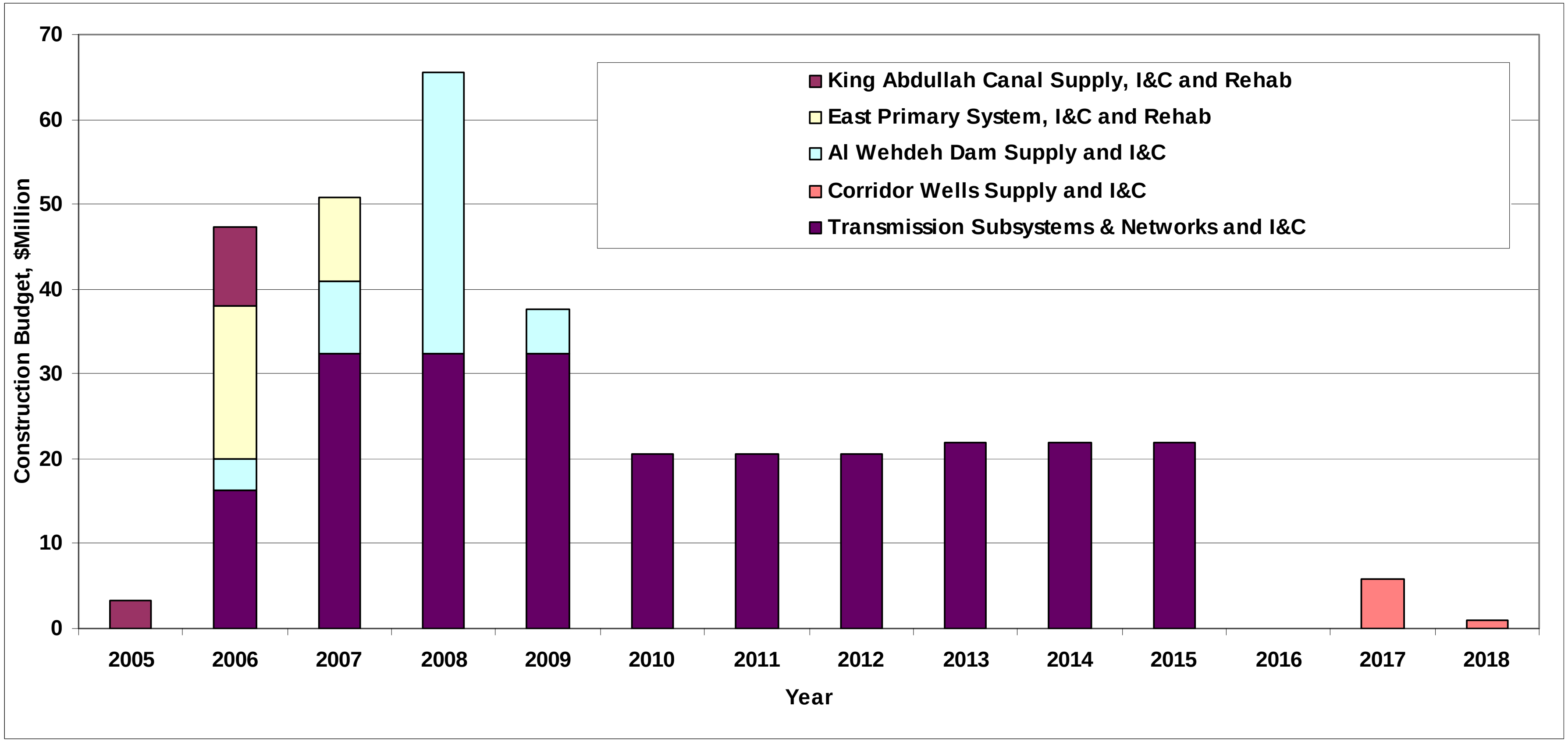


LEGEND

- DN: Conventional design documents, including WAJ review
- BD: Bid documents for design-build
- B/A: Bidding and award of contract period
- DN-BUILD or BUILD: design-build or construction

Notes:
Rehabilitation of existing facilities (mechanical/electrical/instrumentation) not shown
Monitoring and control system not shown

Figure10 Construction Costs by Project / Year



TERMINOLOGY

AGENCIES

GTZ	Deutsche Gesellschaft Fur Technische Zusammenarbeit
KfW	Kreditanstalt Fur Wideraufabu
MWI	Ministry of Water and Irrigation
NGWA	Northern Governorates Water Authority
USAID	United States Agency for International Development
WAJ	Water Authority of Jordan

COMPANIES

CC	Consolidated Consultants
CDM	Camp Dresser & McKee Inc.
MWH	Montgomery Watson Harza

ABBREVIATIONS

$	US dollar
%	per cent
DI	ductile iron
dunum	area of 1000 m2
GIS	Geographic Information System
ha	hectare; area of 10,000 m2
JD	Jordanian Dinar
KAC	King Abdullah Canal
km2	square kilometers
lpcd	liters per capita per day
m	meter
m2	square meters
m3	cubic meters
m3/hr	cubic meters per hour
MCM	million cubic meters annually
mm	millimeter
NRW	Non-Revenue Water [same as UFW]
NWMP	National Water Master Plan
OMS	Operations Management Support
PS	pump station
ROU	Regional Operations Unit
ST	steel
UFW	Unaccounted-For Water
WLRP	Water Loss Reduction Program
WTP	water treatment plant
WWTP	wastewater treatment plant